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CHARON - an image manipulation tool

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Disclaimer

CHARON – an image manipulation tool (U)

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CHARON allows users to perform rudimentary image processing operations without having to learn a complicated image-processing syntax. CHARON was intended to be used with the radiographic simulation code HADES, but is a standalone application that works with images in standard file. (U)

CHARON

The interface to CHARON is designed to feel like a calculator, see Fig. 1, with images taking the place of numbers. Like a calculator, CHARON has a register, buttons representing data (numbers on normal calculators, images in CHARON), and a set of operations than can act on the register.

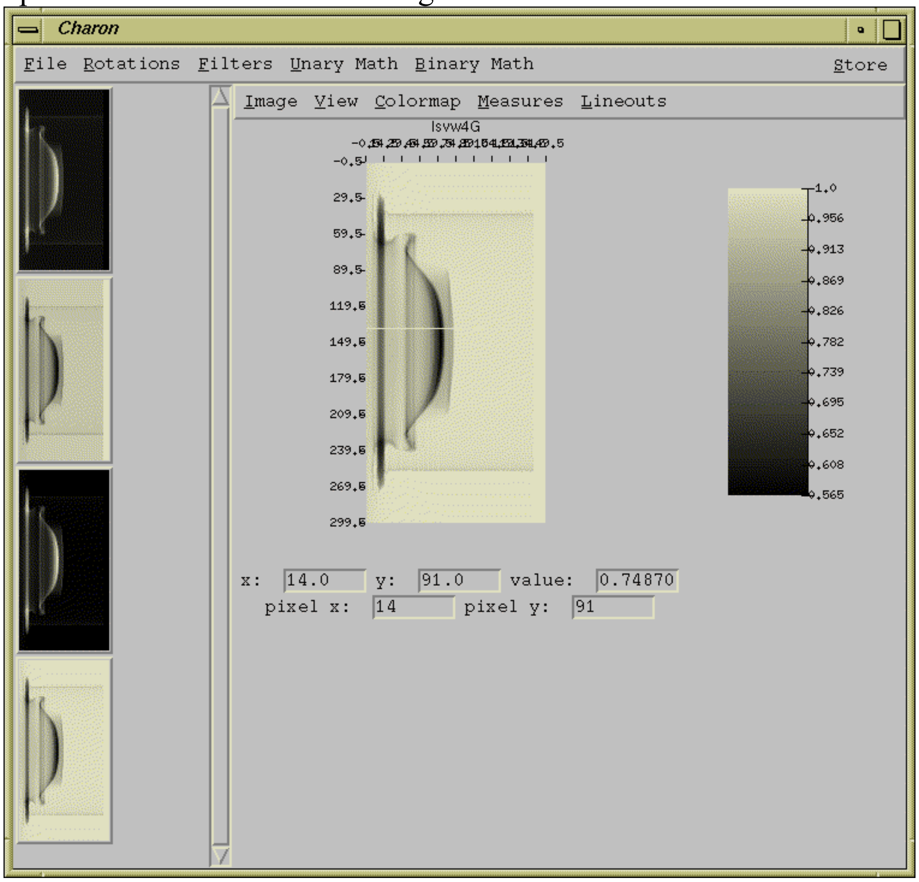

Fig. 1. CHARON main interface

The register holds one image at a time. Operations may change the appearance of the image in the register, but the underlying data is unchanged. Each open image has a thumbnail representation associated with it. The first time an operation is performed on an image, a new image is created for the result, and the image in the register is not lost. However, if a new image were created and stored every time an operation was performed, CHARON would be overrun with images. So, by default, each additional operation result takes the place of the previous image in the register. The result at any point can be explicitly stored as a new image.

In addition to the actual data in an image, each image has a viewer associated with it, responsible for displaying and inspecting the image data. The viewer does not change the underlying data of the image; it is only capable of communicating information about the data. As the mouse cursor moves around the image, the position display shows the exact position of the cursor as well as the image value. A tear off viewer can be used to create a new register for additional images.

Image processing capabilities

Standard image operations

CHARON provides basic image processing operations. There are several pre-defined filters – *e.g.* edge, blur, and sharpen. Other operations include unary mathematical functions, operating on one image – such as exp, negate, sin, and cos, and binary functions – for example add, subtract, min, and max - which operate on two images. Images may be zoomed, using discrete ratios, or rotated. CHARON comes with a number of colormaps, based on the standard Matlab colormaps.. There are lineout tools for horizontal or vertical slices across an image, and arbitrary lineouts within an image.

Atypical image operations

There are several other operations. A background profile can be subtracted from the image, or from masked areas within the image. The profile is assumed to be quadratic in form and a threshold value is used to cap the minimum value of the fitted data to prevent the final image from having negative values. The aspect ratio can be computed, with the corresponding bounding box drawn around the image. Convolution with a top-hat blur kernel is available. A pseudo contour operation transforms the image into a set of levels, defined by the number of discrete levels or a list of level values. Two images may be compared by determining how to translate and rotate the second image in order to make it align to the first. A figure-of-merit is returned along with the translations and rotation.

Statistical resources

Image measures

Statistical information about the underlying image data is available. There is a ruler for measuring distance within the image either between two points, or cumulatively along many points. Moments about the image can be computed. The moments (loosely defined as $M_n = \int |x-a|^n P(x)dx$) are calculated along radial lines centered at a given pixel. CHARON computes Shannon's Entropy metric, defined as $\sum_i p_i \log\left({}^1\!/_{p_i} \right)$. CHARON calculates two ratios. One is the perimeter of the image to its area. The other is the surface area of the rotated image to its enclosed volume. The latter ratio is computed for each of the two half-images, where each half-image is spun around its axis to generate a 3-D volume. Both ratios are non-weighted, that is, the pixel values aren't taken into account, only whether each pixel is on, relative to some threshold. There is a compactness measure defined by $\left[{}^{perimeter^2}\!/_{4 * p * area} \right]$. The fractal dimension of an image can be computed by determining the number of boxes of given sizes it takes to enclose the image and represents non-smooth boundaries better than the perimeter.

Chord length distribution

There are two distributions of chord lengths offered in CHARON. The first computes the distribution of chord lengths seen by rays randomly thrown across the entire image. The average chord length is used to estimate $surfacearea = \frac{4p\langle l\rangle}{12\langle l\rangle}$ and $volume = \frac{16p\langle l\rangle^2}{12\langle l\rangle^4}$ (where $\langle l\rangle$ is the average chord length) of the image rotated along the central y pixel.

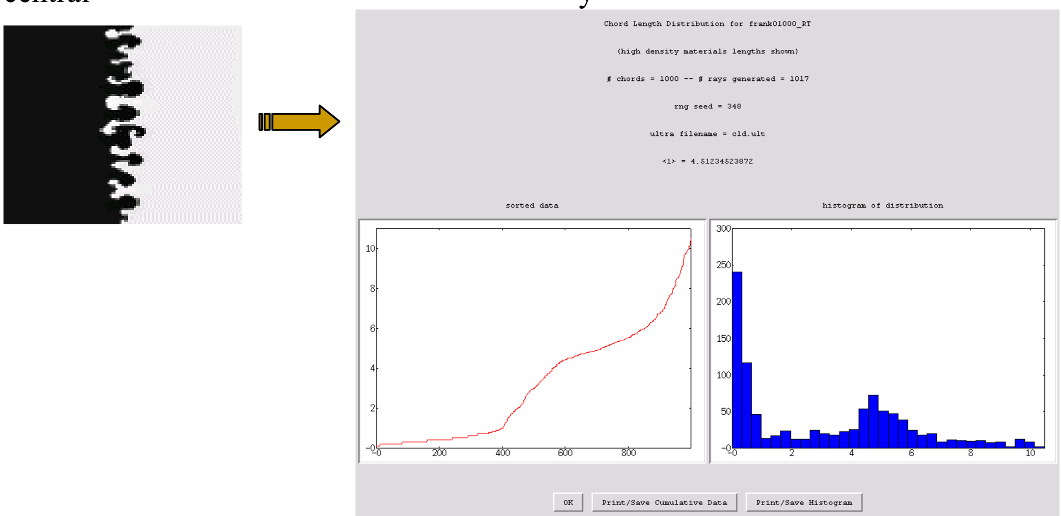

Fig. 2. Rayleigh-Taylor interface and resulting chord length distribution

CHARON generates a chord length distribution that can be used to characterize images. By applying the distribution to various snapshots of a Rayleigh-Taylor unstable interface, see Fig. 2, the onset of turbulence may be determined. In order to use the chord length distribution, a grayscale image must first be converted into a binary image. CHARON prompts the user for a threshold value to distinguish black from white.

Escape distribution

The second distribution works by randomly generating rays from inside the image object and determining the length to the image boundary along random directions. As an example,

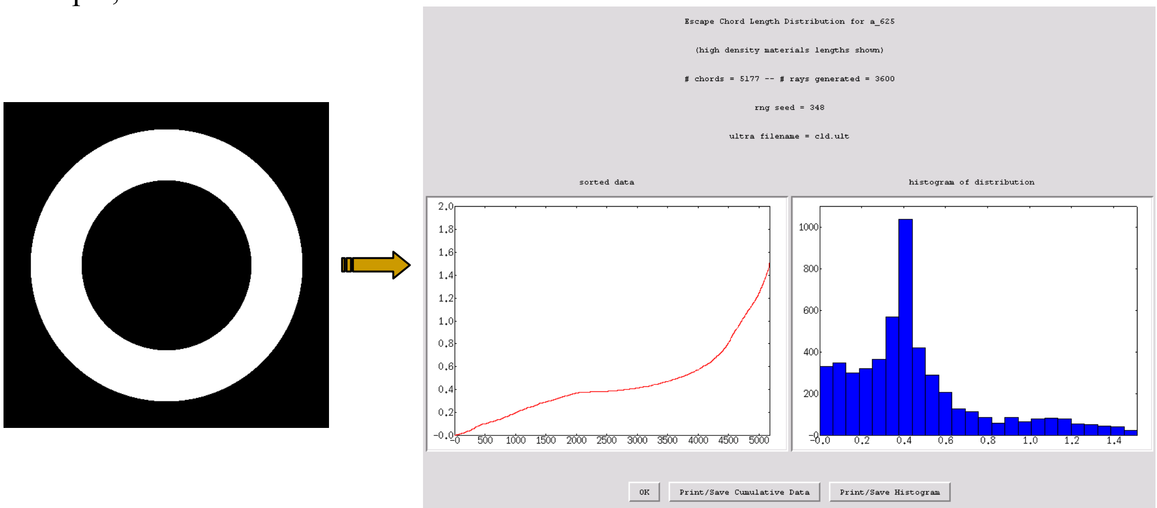

Fig. 3. Annulus and resulting escape distribution

CHARON randomly picks points within the annulus of Fig. 3, generates a circle enclosing the image centered at the point, and starts randomly throwing rays from the point to the circle boundary, keeping track of the pathlengths across the annulus. This metric is also for binary images only.

Integrated distance metrics

A final set of image measures are integrated distance metrics. For all points within the image, CHARON calculates the distance to nearest boundary. The five metrics are:

$\dfrac{\int Di * dS}{xarea}$	$\dfrac{\int Di * dS}{volume}$	$\dfrac{\int Di * dV}{xarea}$	$\dfrac{\int Di * dV}{volume}$	$\int Dc * dS$

Where *Di* refers to minimum distance of a pixel to the interface and *Dc* refers to the distance of a pixel to the center of the image object. For the volume integrals, the object is assumed to have 'cylindrical symmetry' about the axis, with each side contributing half. Fig. 4 contains an asymmetric object and its integrated distance metrics.

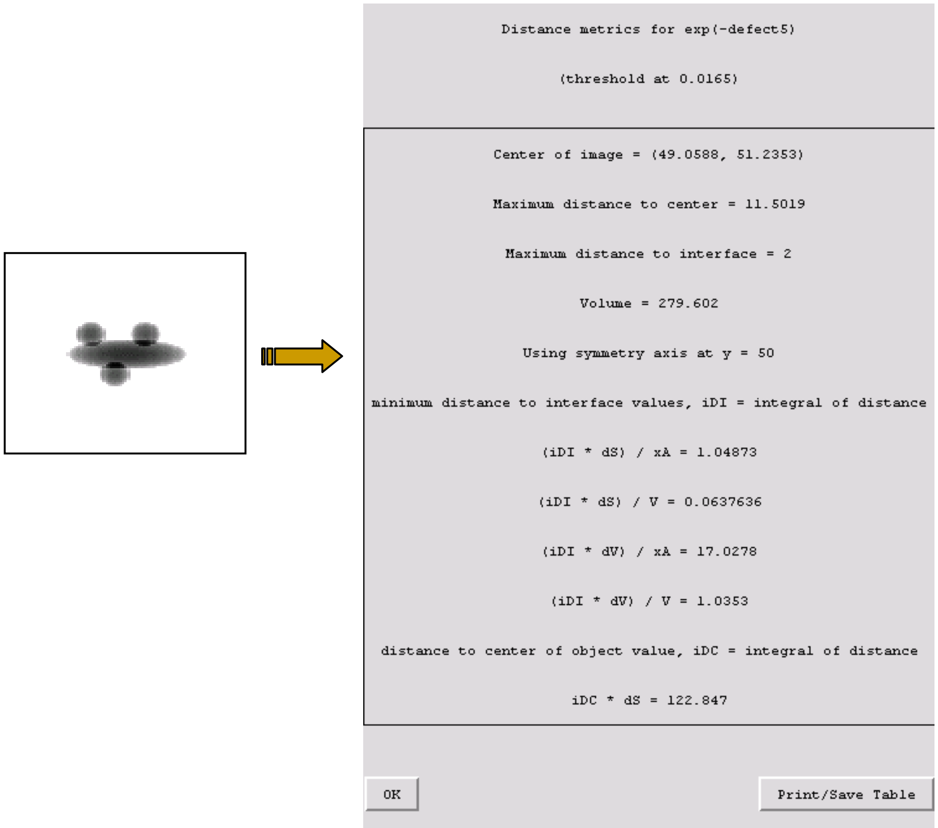

Fig. 4. Asymmetrical image and resulting integrated distance metrics

Pseudo-radiograph

CHARON can process 3D images generated from the non-destructive evaluation community. The files need only be in the appropriate std format. A pseudo-radiograph

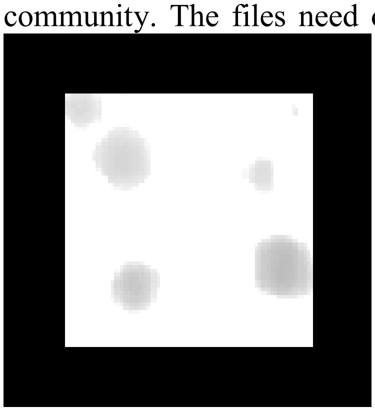

Fig. 5. Pseudo-radiograph (intensity) of shocked Al cube from TMM data

is performed by adding up the images slices along a single axis and normalizing the result. This image (see Fig. 5) can then be compared to an experimental radiograph (see

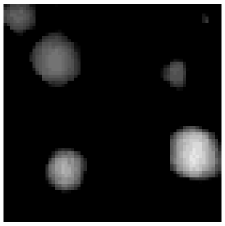

Fig. 6. TMM of shocked Al cube

Fig. 6. An image can also be viewed at any slice for each of the coordinate axis. Intermediate slice positions aren't available since no interpolation is performed between the data slices.

File formats

Images can be saved in any of the basic standard file formats – `jpg`, `gif`, `tiff`, encapsulated PostScript, `fits`, etc. - and three Livermore formats: `std`, `imp`, and `asc`. HADES produces the first format, which is raw binary, and the latter two are used with experimental radiographic images. Images can be sent to a printer. In addition, any of the data or measures plots can be saved or printed, often in tabular form.

Future Work

We would like to add arbitrary rotations as well as arbitrary zoom factors to the code. Other standard image processing operations such as barrel shift and scalar offsets should also be included. CHARON needs a batch mode, so that it can be run from controller scripts. It also needs a command interface in order that user-specified functions can be applied to images. Lastly, we would like to include methods for comparing lineouts, as well as images themselves. For the latter case, it may be possible to make use of either moments of the chord length distribution or exploit the area of the distribution in some normed fashion.

Acknowledgments

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